Journal of the Society of Arts.

FRIDAY, APRIL 27, 1866.

Announcements by the Council.

Ordinary Meetings.

Wednesday Evenings, at Eight o'Clock:—

May 2.—"On National Standards for Gas Measurement and Gas Meters." By George Glover, Esq.

May 9.—"On Military Shooting, and what is required in a Fire-arm by the Soldier." By Colonel Wilford.

Cantor Lectures.

A course of four lectures "On the Synthesis and Production of Organic Substances by Artificial Means, and the Applications which some of them receive in Manufactures," is now being delivered by Dr. F. Crace Calvert, F.R.S., as follows:—

Lecture III.—Friday, April 27th.

"On the Transformation of Organic Acids and Animal Substances."

The artificial production of *benzoic acid* (found in benzoin resin) from the essence of *bitter almonds* and from *coal tar* products, and its conversion into *hippuric acid* (found in the secretion of herbivorous animals); of *tartaric acid* (the acid characterising cream of tartar), from *sugar of milk* and from *succinic acid* (the acid obtainable from amber), and its decomposition into *oxalic* and *acetic* acids—On the transformation of *citric acid* (the acid of lemons and oranges) into *aconitic acid* (found in wolfsbane)—On the transformation of *malic acid* (which characterises the acid flavour of green gooseberries, apples, and rhubarb) into *fumaric acid* (the acid of common fumitory) and also into *equisetic acid* (the acid found in the marsh horsetail), and, lastly, into *asparagine* (the body found in asparagus and potatoes)—On the transformation of *uric*, *cyanuric*, and *cyanic* acids into *allantoin* (the substance found in the allantoid fluid of cows)—On the artificial production of *urea* (a substance which characterises the liquid secretions of man and of many other animals).

Lecture IV.—Friday, May 4th.

"On the Artificial Production of Aromatic Substances."

On the transformation of *salicine* (the bitter principle of the willow and poplar) into the essential oil of *meadow-sweet*, *coumarin*, and of the *tonquin-bean*—On *salicilic acid* and the artificial production of the fragrant essential oil of the *wintergreen*, or *gaultheria*—On the transformation of *indigo*, the *oil of potatoes*, and that of *camomile* into *valerianic acid* (the acid which characterises the odour of valerian-root; the berries of the common guelder-rose; the oil of the fish porpoise, and of certain kinds of cheese)—On the conversion of *essence of turpentine* into *camphor*; of the essential oil of *mustard* into that of *garlic*, &c., &c., &c.

The lectures commence at eight o'clock, and are open to members, each of whom has the privilege of introducing ONE friend to each lecture.

The substance of these lectures will appear in the *Journal* during the autumn.

Central Hall of Arts and Sciences.

The arrangements for erecting a Great Central Hall of Arts and Sciences at Kensington, on the ground purchased out of the profits of the Exhibition of 1851, having been carried so far as to secure the erection of that building, it has been thought desirable that members of the Society of Arts should be put in possession of full information on the subject, in case they should desire to invest in the property, before the whole of the available seats are disposed of. A copy of the prospectus is, therefore, forwarded to each member with the present number of the *Journal*, and the Secretary of the Society will afford any further information on the subject if applied to. A model of the Hall will be on view at the Society's house in a few days.

Proceedings of the Society.

Twentieth Ordinary Meeting.

Wednesday, April 25th, 1866; Sir Daniel Cooper, Bart., in the chair.

The following candidates were proposed for election as members of the Society:—

Carrick, Robert, Chemical Works, Methill, Leven, N.B.
Taylor, Charles W., 167, Great Dover-street, S.E.
Whight, George, Gipping Works, Ipswich.

The following candidates were balloted for, and duly elected members of the Society:—

Brinsmead, John, 4, Wigmore-street, W.
Ellis, Charles Nicholson, 9, Tredegar-square, Bow, E.
Glover, George, Ranelagh-road, Pimlico, S.W.
Glover, George Raleigh, Ranelagh-road, Pimlico, S.W.
Head, John, Mill-street, Kidderminster.
Holdich, William, 105, Fleet-street, E.C.
Niemann, E. J., 19, Charlotte-street, Bedford-sq., W.C.
Pim, Jonathan, 22, William-street, Dublin.
Templeton, James, 7, Woodside-crescent, Glasgow.
Wilson, John C., 5, Lime-street, E.C.

The Paper read was—

THE PERILS OF MINING AND THE MEANS FOR PREVENTING THEM.

By Jabez Hogg, Esq., F.L.S., &c.

Something like an apology appears to me to be due for my appearance here this evening as an exponent of the "Perils of Mining." When I say that to what is already known on this subject I can add but little from personal experience, I scarcely deserve your indulgence for the many shortcomings which will become apparent to many members of the Society during the reading of my paper. Indeed, I should hardly have ventured to occupy your time had it not been for the fact that in the course of my remarks I should have the honour and pleasure of introducing to your notice a refined application of science, one that I trust will be found of great practical utility, for indicating the presence of fire-damp in mines before it becomes dangerous from accumulation. My friend, Mr. G. F. Ansell, the inventor of this Fire-damp Indicator, has not only placed his apparatus at my disposal, but gives me his valuable assistance in demonstrating its various applications. I may first state that it is not my intention to go into the practical details of mining; indeed, to do so

would require an amount of knowledge of mining to which I have not the least pretension; my purpose this evening is rather to speak of the perils attendant upon the miner's work, and what may be done to reduce them to a minimum. I believe you will agree with me when I say that deaths cannot properly be said to be accidental, when the greater part of what are described in the Inspectors' Reports as "deaths from accidents in mines" arise from preventable causes, which a little more care and forethought on the part of the miners, and a little increased expenditure by the mine-owners, might have prevented. It is therefore clearly an error to speak of the greater part of them as *accidental* deaths.

By the great explosion at the Lundhill Colliery in 1857, it will perhaps be remembered that 189 lives were lost, and the Government of the day appointed Mr. P. H. Holland, to report officially on the loss of life. For five months this gentleman was employed before he could ascertain this positively, on account of the difficulty of recovering the bodies. During the time he was so engaged he gained much valuable information upon mining; and toward the end of the year 1859 the Council of the Society of Arts requested him to communicate his experiences "On the Prevention of Accidents in Coal Mines" (*Journal*, vol. vii., p. 37), and a very practical paper was followed by a valuable discussion. It was then argued that from the great increase in mechanical and other contrivances, the death-rate in mines in after years must become sensibly diminished. Mr. Holland showed one lamentable fact, that, exclusive of the miscellaneous fatal accidents, the average number of deaths from explosions for the eight preceding years rather exceeded one per diem. Well, I fear that not so much improvement has taken place as was then expected: for the death-rate is still very large, being six or eight times greater than that for any other dangerous occupation; and the charge of the insurance companies against death by accident in collieries is more than eight times the ordinary rate.*

"If," says Mr. Holland, "this destruction of human life were inevitable, it would be melancholy enough, but I shall convince you that a very large part of it is not inevitable, and that it would be very much diminished if the inspectors of coal mines could succeed in enforcing obedience to their regulations; and that obedience to those excellent rules would be far better enforced if it were made the direct and palpable interest of owners and managers of coal mines to observe and enforce them." In this year of grace, 1866, I fear we must reiterate the same sentiment, and say with this gentleman, that *if* we could *only* get certain good regulations enforced, what a blessing it would be, and how many valuable lives might be saved; but, sad to relate, very little progress has been made in this respect, and we have still to lament the want of co-operation between the miners and the mine owners, which practically nullifies the valuable supervision afforded by the Government.

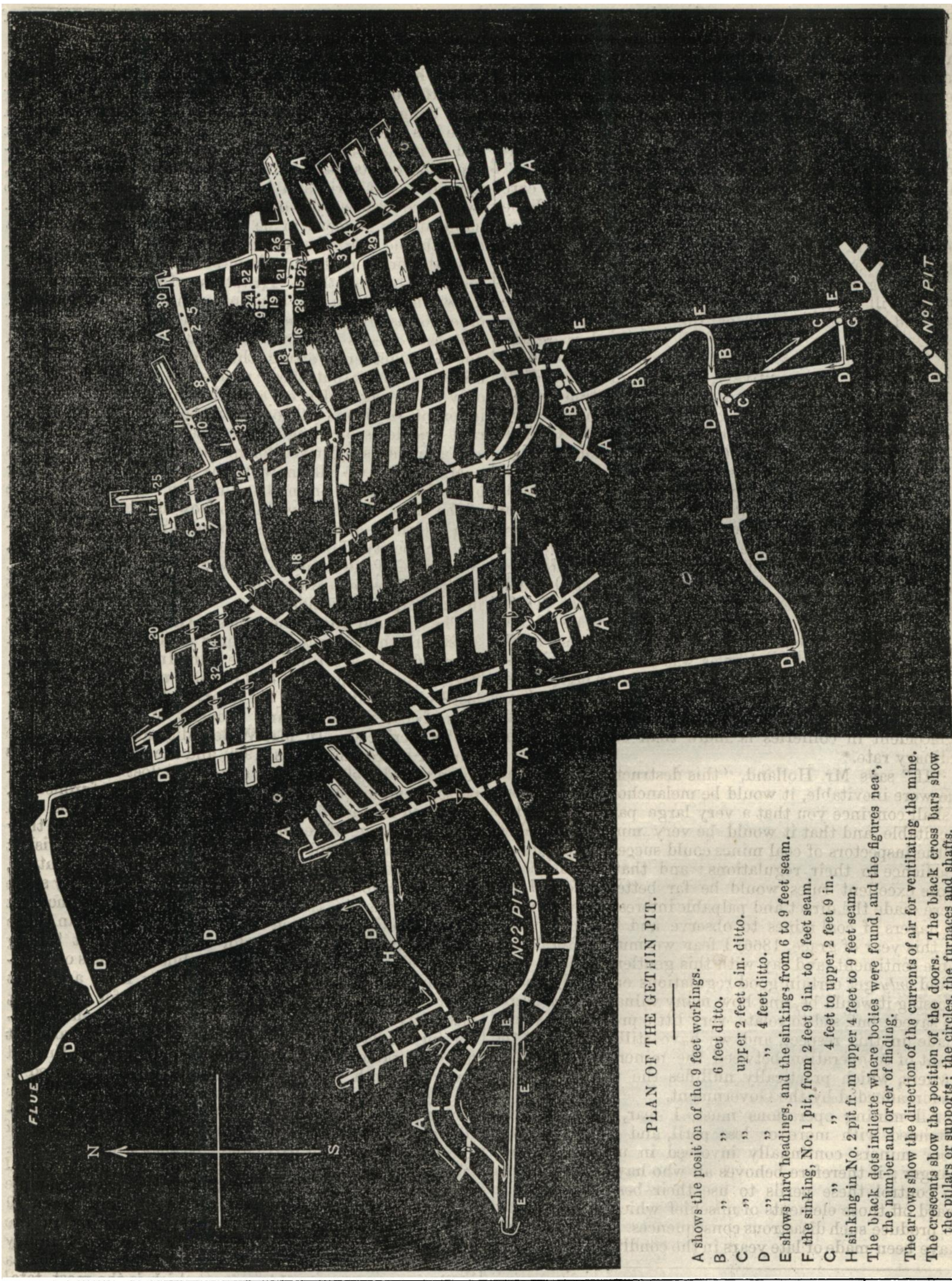
All mining operations must, I fear, be necessarily attended with more or less peril, and the lives of the poor miners continually involved in uncertainty and danger; it therefore behoves all who have any influence to control these perils to use their best endeavours to ward off those elements of mischief which are calculated to produce such disastrous consequences. Improvements have been made of late years in the condition of labourers in all other branches of industry. Even the peasant has risen in the social scale, much as he requires still to rise before he can be said to enjoy a reasonable measure of comfort; but for the miner, whose occupation is at once the most dangerous and the most unhealthy, comparatively little has been done. The public is still periodically startled (if it has not by now become inured to the subject) by appalling colliery accidents, and the miner is still left in ignorance and peril, and has to fight almost unaided his two terrible foes—fire-damp and choke-damp. He is liable at any moment to be burnt to a cinder, or buried beneath the *debris* caused by explosions of the one; he has little or no protection from being choked in his darksome lair by the other. Irruptions of water threaten to drown him like a rat in a hole; and perils in various other forms are ever impending over his devoted head. Not that means do not exist of mitigating at least, if not of altogether averting, the dangers incident to the miner's calling; but these means are not employed, or only in a meagre degree, and the miner himself being ignorant—and superstitious and reckless because ignorant—neglects or altogether refuses many conveniences and appliances contrived for his benefit and safety.

Mining, as we all know, is one of the most important operations carried on in Great Britain; upon the success of the class who burrow in the bowels of the earth and win the riches buried there, depends, in a great measure, the prosperity of several of the great industries of this country, and the comfort of every individual among us; and therefore we are all, more or less, directly concerned in this mining question.

The coal and iron-stone mines of Great Britain number 3,220, and the computed number of males employed in the year 1864 was, according to the Mine Inspectors' Reports, 307,542, and it appeared that of these one life in 354 was lost by accident during the year, and for every 109,715 tons of coal recovered and brought to the surface one life is sacrificed. In Mr. Wales' district the computed number of iron miners is 3,900, and the quantity of ironstone raised, 450,000 tons; one life is lost for every 557 persons employed annually, and 64,285 tons of ironstone are raised for each fatal accident. It will be observed that the per-centage of deaths in coal mines far exceeds that in iron mines, although, in my opinion, the supervision is much more efficient in the former than in the latter. It might have been expected that the more recently sunk mines, owing to the increased appliances of modern science, would have been freer from accidents than those which have been at work for some time. But this is not the case, for we find the old-established mines of West Scotland far better managed and freer from accidents than those newly opened in South Wales, for while the latter have one man killed for every 277 colliers employed, the former have only one for every 622, a remarkable and deplorable difference. So many more lives are thrown away in South Wales because the precautions proved to be effectual in West Scotland are not observed in Wales. There is, however, another reason for this unpleasant difference; it is the fiery nature of the coal in some of the pits, Merthyr in particular; so that when an explosion does occur, it is productive of the most fearful destruction to life. Of this we had a melancholy example in the recent accident in the Gethin Colliery, when 40 lives were lost, and out of 60 persons working in the pit at the time of the explosion only 13 escaped injury of some kind or other. Early in February, 1862, a similar occurrence in this mine, which is the most fatal in the district, was attended by still more fatal results, when 47 miners miserably perished. After a protracted and careful investigation made at the time, the management and system of ventilation* were particularly con-

* For the numerous evils and great loss of life which occur in mines, Mr. Holland proposed a plan of life insurance, and argued that "such a system, by showing the men that their lives were valued, would lead them to value them themselves." Lord Campbell's Act can be rarely applied in colliery accidents, since it is absolutely necessary to prove that death resulted from the neglect of the defendant, that is, the mine owner; so that life insurance appears to offer the best means of meeting their cases, and especially so if the insured can arrange to share the profits of diminished accidents; for then "the motives to carefulness and good management would be still more increased."

* It is expressly enacted in the 4th section of the Colliery Inspection Act, that an "adequate amount of ventilation shall be constantly produced in all collieries, to dilute and render harmless gases to such an extent as that the working places of the pits and levels of such collieries shall, under ordinary cir-



PLAN OF THE GETHIN PIT.

A shows the position of the 9 feet workings.
B " " 6 feet ditto.
C " " upper 2 feet 9 in. ditto.
D " " 4 feet ditto.
E shows hard headings, and the sinkings from 6 to 9 feet seam.
F the sinking, No. 1 pit, from 2 feet 9 in. to 6 feet seam.
G " " 4 feet to upper 2 feet 9 in.
H sinking in No. 2 pit from upper 4 feet to 9 feet seam.
The black dots indicate where bodies were found, and the figures near the number and order of finding.
The arrows show the direction of the currents of air for ventilating the mine.
The crescents show the position of the doors. The black cross bars show the pillars or supports; the circles, the furnaces and shafts.

demned; nevertheless, so little were the lamentable results and the warnings heeded, that in less than four years we have to place on record an almost equally fatal catastrophe. The coroner who sat to inquire into the late accident said, in the course of his remarks to the jury, that, "according to the returns for the year 1864, there were no less than 101 separate accidents from fire-damp in the coal mines alone of the South Wales district, involving the loss of 105 lives;" and this estimate is exclusive of accidents in ironstone mines. When the number of these accidents is compared with the quantity of coal

cumstances, be in a fit state for working." It is, however, quite impossible to give effect to this enactment, neither can it be made to meet extraordinary and sudden accumulations of gas.

drawn, the average is greater than in any of the other ten districts into which England is divided, and more than twice that of the three principal ones, viz., Northumberland, Cumberland, and Yorkshire. The returns for the year just passed (1865) will present a more gloomy aspect. They have not yet been made up, but from my own experience I can safely say that the numbers in this district will be fearfully augmented, as I have already had in my division alone during the past year nearly 100 colliery cases, exclusive of the one on which we are now engaged. These facts are very melancholy to contemplate, and appear to indicate the necessity of some parliamentary inquiry, with the view of ascertaining whether some more effectual measures could not be adopted, and some improvement effected, and I sincerely hope that the legislature will be induced to take up the matter and institute some inquiry."*

Inquiry after inquiry has been instituted by the government; indeed, a committee of the House of Commons is once more engaged upon the subject. Unfortunately little good has hitherto resulted. No investigation can be of any use unless it is followed by more stringent rules, compelling those in charge to use more caution than is now customary. So essentially dangerous is the duty of the miner, that it is not to be wondered at that the caution which the presence of danger instils into most minds should not be very highly developed in those who have chosen mining as a mode of earning a living. If the officials in charge of a mine care so little for the results as to leave all to blind chance or next to it, since they consider their duty done when they have hoisted a danger-signal, it is not to be wondered at that the more ignorant workmen should err on the same side, and blindly walk into the very jaws of death with an open lamp to light them on their way. And, with but few exceptions, to a more or less culpable extent, carelessness is at the root of all the sad and terrible disasters attendant upon the firing of a pit. In addition, it must be remembered that the whole body of miners are fatalists of the worst class, implicitly believing that they will not die until their time comes, and that when it does, die they must, and hence they run most foolhardy risks. This belief, however, makes them courageous even to a fault in endeavouring to save fellow-workmen requiring help.

It will be well to enter a little more fully into the circumstances attendant upon the late explosion in the Gethin mine, as they are peculiarly instructive, and clearly show the wide-spread destruction produced by these gas accidents. By the kindness of Mr. C. H. James, I am in a position to make this quite clear. This gentleman visited the mine immediately after the accident, and carefully noted the position in which each corpse lay, as numbered and shown in the plan on the preceding page. This plan was produced at the Court of Inquiry, and, therefore, is authentic and truthful.

The Gethin mine is an extensive colliery, comprising several pits now connected together. There are two winding shafts, which are used as downcasts for supplying the workings with air, and they have one upcast flue in connection with them. No. 1, or the lower pit, is sunk to the 4ft. vein, and used for that and for the 6ft. working. No. 2, or the upper pit, is sunk to the 9ft. vein, and is used entirely for that vein. The explosion took place here, where the ventilation is split into different portions. Ventilation is carried on by means of two furnaces (circles shown in plan) situated near the bottom of the flue pit. The length of the current of air which supplies the No. 1 pit is about three-quarters of a mile, while that of No. 2 is about a mile and a quarter; this is a good deal increased by the splitting up it undergoes in supplying the various stalls. The 9ft. coal is worked by pillar and stall, as you will see by the plan. The coal in this district dips, as a rule, at the rate of 3in. per yard to the south. The pit is sunk in such a position as to have all the coal to be worked lying to the "rise," or north of the pit. When the coal is won, levels are driven from the pit east and west; from these level headings, cross headings are driven to the north or rise every 60, 80, or 100 yards, and from these the stalls are turned. The headings are about 7ft. wide, and, in all cases, high enough for a horse to travel along. The stalls vary considerably in width, ranging from six to 20 yards, according to the thickness of the seamstep. The pillar, or coal left between the stalls, varies from 12 to six yards wide, the communications between the stalls being called cross-holes or thirlings. The arrangement of the seams is as follows;—The upper 4ft. is the upper seam on the plan; 20 yards or so below is the upper 2ft. 9in.; five yards below that is the 6ft.; and 30 yards below again you have the 9ft. The ventilation was apparently all correct up to December 15th, when, for some reason or other, a change was made in that portion of the mine where the accident occurred, and the consequence was that in a couple of days a considerable quantity of fire-damp accumulated at this part of the workings; and, although the foreman thought it dangerous, and had "the danger-signal put up" (which consisted of only two cross poles) to warn the men of the danger, yet it was no one's business to see that the gas was driven out, or any great change made in the current of air: and we have it in evidence that the man in whose stall the gas first began to accumulate was a steady workman of some 20 years' standing, fully aware of the danger attending the accumulation, as, indeed, were many of his fellow-workmen, for, as one of them said, "it was so full that there was enough fire to blow the pit to pieces." All, however, went to work as usual, hardy, rash, and reckless, and in about an hour after a workman said he "felt a ringing noise in his ears." when he started up and shouted out "the damp is off," and the last sight that met his eyes was a man blown into the "sump" (the lower end of the shaft), and stones went flying about in all directions. In a moment, the already long catalogue of misery and death was increased by the loss of 40 strong men and the heartrending wailings of widows, orphans, and dependent relatives, to the number of 81.

Mr. Brough, the government inspector, said that while underground with Mr. Wales, examining into the cause of this accident, "they met a young boy going in with an unlocked lamp, and more than one lamp found after the explosion was also unsecured. The colliers are permitted to buy their own lamps, manufactured anywhere; whereas, if the owners were to supply all the lamps, they would, in all probability, have them carefully made by the best makers. The ventilation, also, although he could scarcely say it was insufficient, had to travel in out in various directions and through intricate and tortuous underground pits or staples; so that only in the event of all going smoothly and remaining in a perfectly sound condition,

* This year promises to supply a list of casualties equal to former years. A fearful explosion happened on January 27th, 1866, at the Highbrook Colliery, near Wigan, which occasioned the loss of 30 men and boys. On the morning of the accident the fireman, William Marsh, reported the mine as free from gas, and about 50 labourers descended as usual to their work. All was well till noon, when the foreman went to the "pit's-eye" to get something to eat. On his way back to the far-workings he was met by a blast of wind coming along with such violence as to lift him off his feet. The underlooker, Henry Ascroft, was down in the other pit at the time, but he joined Marsh in a few minutes, and an examination of the workings was made. As they were proceeding they stumbled across three boys, two almost in the last stage of suffocation, but they quickly recovered on being conveyed to the fresh air. A short distance further an arch over the return air course was found blown down, completely stopping the whole ventilation beyond that point. This was about 140 yards from the pit's-eye and 240 yards from the end of the working. About two hours after the accident the first dead body was found and forwarded to the bank, where, before night, there was a hideous row of 30 blackened corpses. The cause of the explosion is, as usual, enveloped in mystery, as all those who perhaps could have thrown any light upon it were silenced in death.

could this mine preserve its proper balance, and be said to be prepared to meet a sudden danger. Even after the accident, three accumulations of gas were found, one in a hole in the roof of the middle level, and the others in two old stalls, and no attempt had been made to remove them. Indeed I was informed," continues the inspector, "by the officials of the pit who accompanied me, that they had not known of these accumulations until after the accident; and although, at the time of my visit, the air was travelling from these dangerous spots to the working-stalls, the men employed there were still 'firing shots,' *i.e.*, blasting with gunpowder."

So much for the care exercised by those in authority over this fiery mine at Merthyr; indeed Mr. Brough's last report fully bears out what has been stated with regard to the difficulty of guarding against sudden accumulations of gas, because of acts of gross carelessness on the part of those in charge of even well-regulated mines. In another instance, Mr. Brough tells us that the "haulier" left doors open which turned the air in another direction, after the workmen had left off work for dinner, thus changing the current for one hour only; during that time a considerable quantity of gas accumulated in the workings, and upon their return, the men, not knowing what had been done, entered the workings with naked candles; an explosion which killed four of them immediately ensued.

We will take another case from Mr. Wales' report, because it forms a contrast to the last one, which might be said to be hardly a fair illustration of pits in general, as it was known to be of a dangerous character. This explosion occurred in a mine belonging to the Aberdare Iron Company, Glamorganshire, which is described as by no means a *fiery vein*, and therefore excepting where ordinary measures for safety are entirely set at nought, such an accident ought never to happen. The part of the mine in which this explosion happened was in course of rapid extension through a large fault, and the quantity of air passing through was very small indeed, not more than 2,000* cubic feet per minute, and this was borne round the whole of the workings in one continuous current, thus necessitating the use of several doors, none of which were doubled, so that even this very bad ventilation was liable to be cut off either by neglect or injury done to any one of these doors at any moment. It came out in evidence, also, that no examination of the workings had been made previous to the workmen going into their stalls, in one of which an accumulation of gas had unexpectedly taken place. A workman entered this place with a lighted candle, and the gas was instantly ignited, and he, with two of his fellows, were killed. Now, it will scarcely be believed that in this instance the defective arrangements in the mine were duly communicated to the proper quarter, and yet nothing was done to avert the evil; the men were allowed to work either with safety lamps or naked lights, just as they thought fit. So that we see, on turning to any of the inspectors' reports, that precautions and regulations are openly set at defiance or systematically neglected, and that a very large proportion of the hundreds annually killed in mining are culpably destroyed in consequence of such neglect.

It must not, however, be supposed that by the enumeration of losses of life by fire-damp we fully realise the extent of the evil going on year after year; it appears that the gross total of actual deaths in 1864, from accidents in and about the coal and iron mines of Great Britain, was 963. The following tabular arrangement shows at a glance the every-day dangers of miners:—

DEATHS.—IN THE SHAFT.

From overwinding; that is when the engine is not stopped in time, and the tub being drawn over the pulley, the miners are thrown bodily down the shaft	8
From falling, either from the surface or from part of the way down the shaft, *e.g.*, as where the same shaft works two seams of coal or ironstone	63
From things falling all or part of the way down the shaft	22
From breaking of ropes or chains; that is, the ropes or chains which raise and lower the tubs, cages, &c.	19
From accidents while ascending or descending, such as from falling off the tub or cages, or being struck by the return tub	54
From miscellaneous accidents in shafts	46
Total in shafts	212
IN THE PIT.	
From explosions of fire-damp	101
From explosions of gunpowder	20
From suffocation by gases	11
From falls of coal or ironstone; that is, falls of detached masses which are imperfectly propped, or which fall before expected	133
From falls of roof; that is, fall of stone from the roof or sides of the galleries	305
From miscellaneous accidents underground	108
Total in pit	678
ON THE SURFACE.	
From machinery	15
From bursting of boilers	10
From miscellaneous accidents on surface	48
Total on surface	73

Grand total in all parts of mines 963.

The numbers in this table need a word of explanation, for we see it stated that the actual number of deaths from fire-damp was 101; but it must be understood that deaths after removal from the pit, which amounted to 20, although resulting from explosions, are not generally included in this list by the inspectors; nor are deaths from suffocation by after-damp, and the gases liberated by blastings, which amounted to 11, and are included amongst the miscellaneous accidents. Neither can we form the least idea of the very large number of workmen maimed and injured for life by explosions. Mr. Atkinson, speaking of the serious personal injury occurring from non-fatal accidents, says:—"The reports received are of little value in a statistical point of view, for besides the persons injured by slight explosions of gas, 17 other non-fatal accidents were reported, by which three deputies and seven other workmen were injured by falls of stone, and one person crushed by a coal tub. Four persons were injured by the breaking of a winding-rope, while they were ascending the shaft, and two others suffered injury by being jammed by coal trucks and waggons on the surface railways, near the tops of shafts." Mr. Brough gives a list of 197 accidents to 92 persons killed. "This account," he observes, "of deaths, contusions, fractures, amputations, &c., sounds more like the description of a battle-field than the ordinary report of industrious and peaceful pursuits; nevertheless, year after year, the same melancholy record has to be made out and submitted to public notice." Among the miscellaneous accidents in Mr. Baker's report, there is one which so fully illustrates the proverbial carelessness of the workmen that I cannot refrain from quoting it:—"The store of gunpowder used for blasting was kept in the blacksmith's shop. One day, when filing a piece of red hot iron close to the chest in which he had placed a barrel containing 28 lbs. of gunpowder, a frightful explosion occurred, which rent the chest asunder, razed the shop to its foundations, and injured the man so severely that he died a few days afterwards." Most culpable accidents arise from falls

* The average quantity of air passing through the House of Commons is 8,000,000 cubic feet per hour.

down the shaft. Only just think of the mouth of a pit yawning before you without any kind of protection round it. Mr. Baker furnishes the particulars of a very remarkable accident arising from this neglect in one of the South Staffordshire mines. A horse was being harnessed in a stable near the pit, when he suddenly became restive, knocked down his attendant, and bolted out of the stable, making directly for the open shaft, down which he went. Unfortunately six workmen were at the time descending; the horse fell upon them, precipitating the whole to the bottom, a lifeless heap.

The large number of deaths from falls of roof and coal are due to imperfect inspection, or to too close working; a good deal of course must be due to the want of skill on the part of the miner. The successful introduction of coal-cutting and boring machines, driven by compressed air, will prove a valuable means of prevention of accidents of this nature, and go far to increase the safety of the men employed in driving-headings; besides which it will at the same time incidentally assist the ventilation, by the escape of the used and liberated air at the point where a purer atmosphere is most needed. In an economical point of view machinery must prove of importance. For instance, in undercutting coal by hand the opening must be wide in front and about three feet deep, or it will be impossible to get at its inner portions; the coal thus removed by the miner is so small as to be almost valueless; whereas, when the cut is made by a machine it is so narrow that a great saving will thus be effected. As soon as the cut is sufficiently deep the coal falls by its own weight, or is forced down by wedges; but should it fall suddenly there is no danger of crushing and burying the miners alive.

But accidents are not the only evils with which the miner has to contend. His occupation is itself unhealthy, and, as at present conducted, involves a serious curtailment of his natural period of existence. The atmosphere he breathes is impure; the positions in which he labours are irksome and injurious; and the incrustation of his skin with dirt is deleterious. The result is, that in Cornwall, between the ages of thirty-five and forty-five, fourteen miners die for every ten workers above ground; between forty-five and fifty-five, thirty-four miners perish for every fifteen workers above ground; and between fifty-five and sixty-five, no less than sixty-three miners succumb for every twenty-four toilers on the earth's surface. All these calculations deal with males only; but, as it seems females are also employed in considerable numbers underground, the mortality must be still greater in proportion among them. And if we dive into the every-day life of these people we shall cease to feel surprised either at this lamentable death-rate or at the deterioration of health that must of necessity occur in an underground existence.

"In deep cold metal mines, where a few narrow pits open about the same level, stagnation is the rule.* If the average temperature inside be 60° and outside 61°, there is nothing to lift the lowest stratum of air. There is no din, no rattle, no movement here; a dull, sleep-creating sound comes faintly in from a big water-wheel, which is slowly turning and pumping water up from a neighbouring hole. The only cheering sound about the place is the rattle of hammers and stones outside, where boys and girls and strong-armed women are smashing and washing ore in sunlight and fresh air; their cheeks are ruddy, and their eyes bright; but down in the dark well are sickness, silence and gloom." * * *

"On the floor of a coal-mine the footing is sure, but not so in a metal mine, as here the passages, being made at different levels, are full of pitfalls. When the level is reached, a miner leads the way, and an incessant cry is taken up and passed along of 'heads,' 'shoot,' 'lump,' 'deads,' &c., as certain dangers are approached and passed, and in a short time everyone is wet, hot, greasy, smoky, and muddy."

* J. F. Campbell's "Frost and Fire," vol. i. p. 54.

"Having driven two long caves, one above the other, so far that candles will no longer burn at the ends, and men can hardly breathe, the next step in metal-mining is to 'rise' and 'sink,' and join the caves; to make a passage for air to move through, if nature so wills. It is easier to rise than sink, for loose stones fall when blown out of the roof; and the stones which are quarried at the top are thrown down, and gather in a conical heap below, so that the place is well called "a close end."

"In order to get oxygen into this black hole a small boy is stationed at some place where the air is thought fit for use, with a circular fan and a leaky tube. Air of some sort is driven to the end, and half-choked men and dim candles struggle on for life in the burrow. The only air-engine found working in one big mine was a piston in a rough deal box, a panting, short-armed little boy pulled and pushed at the cross handle. The air was close where he worked, and the squirt and its pipes leaked. A long way off, at the end, a very faint puff, which gently bent the flame of a candle for a moment, was the sole result of each violent effort. Three men and three candles were spoiling air thick with old powder smoke, and the place was suffocating, for the boy himself consumed more air than he supplied. He could have blown a candle out with his mouth, he could not with the air-pump. The heat of the men and their lights moved more air than this engine of one-boy power. One effect of these close ends, on one who is unused to them, is to cause perspiration to break out freely while standing still or sitting quietly, although the thermometer marks 64° or less. There is a feeling of tightness about the neck; the chest heaves with a gasp instead of rising steadily; and generally there is distress and a feeling like nightmare. Men at work in bad places pant and seem to breathe painfully; their faces are red or purple; their veins swelled; their brows wet and begrimed with soot. They seem to labour hard, though their work is not harder than quarrying stones elsewhere. In such places candles flicker, and sometimes go out altogether; no puffing or drawing will light a pipe or keep it lighted. There is no laughter, no fun; no busy cheery clatter of active labour at close ends; there is silent toil, for carbonic acid gas is not laughing gas." * * * * *

"To return to upper air fom the bottom of a deep mine, the amateur miner follows his guide up perpendicular ladders, perhaps in the pumping-shaft, with the rods moving up and down a few inches of his back, and foul mine-water dropping on his head, and at last emerges greasy, muddy, drenched, streaming with perspiration, with throbbing eyes, giddy and gasping like a fish out of water, and when the trap-door is passed, the first long draught of the clear, pure air of heaven seems too strong, it flies to the head like brandy; even miners who are used to such places often stagger and reel like drunken men." Such is the condition of a Cornish metal mine.

As regards remedial measures it seems clear that all accidents arising from breakages of machinery, faulty construction of shafts and workings, carelessness of management and recklessness of the workpeople, are certainly preventible, and therefore ought to be dealt with by the punishment of those who are responsible for the observance of the proper means for their prevention. No doubt systematic inspection has induced the adoption of many precautionary arrangements, and thereby hundreds of human lives have been saved; but this has not produced all the improvements of which mines are susceptible, and from the very nature of the case it never can. Making proprietors of mines personally responsible for their parsimony or want of due diligence would go far to check the description of accidents just alluded to; and this should certainly be done. No man has a right to jeopardize the lives of others in order to save himself trouble or expense. Then, again, much good may be done in lessening the amount of the present evil, if some trouble were taken to instruct the workmen as to the

source of the dangers which beset them, and thus to induce them to use all possible means of precaution.

Science has provided us with weapons with which to combat such potent demons of the mine as fire-damp and choke-damp. For the first there are the Geordie and Davy-lamps, which, if properly constructed and carefully tended, not only indicate danger, but may avert the consequences ; but the lamps, though valuable, are at best but imperfect protectors, as I shall presently show, but they are often ill-constructed, and still more frequently most carelessly handled. The light they give is feeble, and this is made so much worse by bad ventilation that the miners are frequently induced to tamper with them. There is likewise now offered for the benefit of miners and mineowners, the simple and beautiful "fire-damp indicator," invented by Mr. Ansell. With this instrument the smallest per-centage of either fire-damp or choke-damp is immediately detected. But before we enter into this part of the question, let us first glance at what is done for miners by ventilation ; and then endeavour to comprehend the nature and properties of the gases which accumulate to a dangerous extent.

The ventilation of mines is obliged to be carried out artificially, although, of course, in obedience to known natural laws ; the method is by heating air in one shaft, and letting cold and fresh air be drawn down another, or by dividing a single shaft and turning the furnace fire up one side. By partitions, doors, screens or brattices, the downward current is made to flow wherever it is wanted to dilute and carry off noxious gases, and at the same time supply men, horses, lamps, and fires with pure air, without which they cannot breathe or burn. We have just seen what a bad system of ventilation does for the Cornish miner, or rather what it does not do ; namely, give him a sufficient supply of oxygen to maintain him in health and strength.

The proper ventilation of a mine has always been a difficult subject to deal with, since it is constantly liable to all kinds of disturbances and impediments. In some mines the ventilation is entirely effected by what is termed the natural heat of the mine ; in one of the Yorkshire pits, left for six years to self-ventilation, the force of the current was strong enough in winter to blow out naked lights, but as summer advanced and the temperature of the surface increased, the force of the current gradually diminished, until it became inapplicable, and ultimately artificial heat had to be employed. The only dangerous gas to deal with in this mine was constantly-accumulating carbonic acid. In the Tyne Main Colliery the natural heat at one time produced a draught of 34,955 cubic feet per minute; nevertheless with this enormous draught of air this mine has not been free from dangerous accidents. We see, therefore, that natural, or self-ventilation is not to be depended on, for the very reason that, in hot weather, the downcast draught is nearly the same as the upcast, and the weight, or pressure of the two columns of air is so nearly balanced that ventilation comes to a stand-still.

Mr. Atkinson, in the report of his inspection of the Cassop Colliery, in July last, said that he found the ventilation of the mine most insufficient, chiefly because, owing to the hot weather, the air descending the downcast shaft was nearly as warm and light as that ascending the upcast; and that in consequence of firing shots, and the great increase in the quantity of stythe or carbonic acid, and the absence of oxygen, lights burned dim and the men could not proceed with their work.

There was passing through the Lundhill Colliery a large quantity of air to take away a quickly accumulating amount of gas, but too late the discovery was made that the current was altogether inadequate to effectually clear out every part of the mine; and consequently one fatal morning the mine was fired, 189 lives were lost, and £20,000 worth of property destroyed. At Risca and Cymmer a large current was passing at the time of the well-remembered loss of life in these mines. It is then quite apparent that unless a sufficient quantity of air can be sent into a mine and made to split up and reach *every* part of it the ventilation will be imperfectly carried on. The object to be attained in every mine is to divide an accumulating amount of gas, and not only remove it quickly and perfectly, but, as far as possible, in separate currents. From the difficulty of doing this, it happens that "close ends" abound in nooks and corners of mines in spite of "windyrings," "windylators," "fans," and "water-blasts."

A good deal more might be said upon this practical part of our subject, but it would only bring us to the same conclusion, that the best method of ventilation is unequal to meet all the difficulties of mining operations, such, for instance, as "blowers," by which is meant a cavity in the coal that has served as a receptacle for collecting a considerable quantity of gas, which is instantly liberated by a stroke of the pick; or again the chance breaking in upon old workings, which, having been closed up for years, accumulate an immense quantity of gas ; or, the gas having collected in a "*goaf*," is retained there by the high pressure of the atmosphere as indicated by the barometer. Suddenly the barometer falls, the mass of gas expands, and some unfortunate workman, not knowing what has happened, walks into the danger with a naked light, thereby exploding it may be acres of gas. Indeed, it is out of the question to make a system of ventilation so perfect as to meet all the hidden dangers of different times and seasons.

Fire-damp is inflammable, burning with a luminous flame, and in its combustion forming water and carbonic acid. A mixture of fire-damp and air, containing six per cent. of the gas, burns quietly ; if the quantity of the combustible element be increased to seven per cent., the mixture explodes feebly; the most destructive explosion taking place when ten and a half parts of fire-damp are mixed with eighty-nine and a half of air. Fire-damp, fortunately, requires a high temperature to ignite it, but by its combustion it produces a still higher one; consequently it singes off the hair, burns the skin, sets fire to garments, and at times even to coal ; hence we occasionally hear of mines being on fire. The gas has a peculiar odour, which, however, varies considerably ; in some mines it has a faint smell of alcohol, in others of tar, and again in others it has a fœtid odour not unlike fennel. For experimental use it is readily procurable, being eliminated when a mixture of equal parts of acetate of potash, caustic potash, and quick lime is strongly heated. It occurs naturally as a result of the decomposition of vegetable matter contained in the mud of stagnant water, such as rivers, ponds, marshes, &c. ; hence its name marsh-gas. The explosive power of this gas, and its capacity for dealing out death and destruction far and wide, may be gathered from the scientific evidence adduce at the time of the Hetton Colliery explosion, December 20, 1860. It was pretty accurately ascertained that the flue in which the accumulation of gas occurred held 7,000 cubic feet of fire-damp. This quantity of gas, when exploded or ignited, expands into 56,000 feet, and is then immediately converted into after-damp. The temperature of the gas on its ignition is raised to 1,500 degrees Fahr., that is, to a bright red heat; and the explosive force of such a quantity of gas as I have just mentioned is equal to that of 1,875 lbs. of gunpowder. Gas is pressed upon in the workings by the great weight of the atmosphere ; therefore to take off the pressure is to liberate the gas ; and as the pressure of the atmosphere may be one day equal to 15 lbs. to the square inch, and the next to only 14 lbs., it will be seen that from this cause alone a mine may be well ventilated one day, and the following only imperfectly. The miner, when he sees a cloudy, wet morning, says, "Ah! I shall not be able to work to-day," and goes to the mine with a heavy heart, and there finds the accumulated gas too much for him ; nor will the best ventilation "sweep it out" in a hurry.

It is well known to those accustomed to mining

operations that there are three kinds of gases met with in mines, all of which are most destructive to health and life, and their nature should therefore be clearly understood in dealing with the important question of the perils of mines. First, the *fire-damp*, or light carburetted hydrogen, which ascends to the top of the workings; secondly, *white-damp*, which is a mixture of 8 parts of nitrogen with one of carbonic acid; and lastly, *choke-black*, or *after-damp*, which is carbonic acid alone, and which, from its weight, occupies the floor of the mine. The carburetted hydrogen is much lighter than common air, 2 cubic feet of it weighing only a fraction more than one cubic foot of air; therefore it spreads out over the roof of the mine and overflows into the workings, especially, as before stated, during certain changes in the weather. The choke-damp, from its great specific gravity, settles down on the floor, and unless the air is passing through the workings and upcast with considerable velocity, there it remains, like mud in water. The carbonic acid in mines, as well as in every-day life, "increases with the activity of life, and with artificial warming and lighting, as well as by animal and vegetable decay. It follows us everywhere, living or dying, and we can only get rid of it by keeping in the natural currents of the air. In a closed space the capacity of the air to support life or combustion diminishes regularly in a manner more consistent with the idea of the activity of the acid than the absence of oxygen."*

Another important element in the deterioration of health arises from the variable quantity of oxygen found in mines. Dr. Angus Smith says:—"In sitting down with the workmen at the 'ends' to compare the sensations of breathing above and below ground, I soon found that air having the normal quantity of oxygen and carbonic acid was quite the exception." Mr. P. Moyle examined the air of the Cornish mines and found them all deficient in oxygen; the average gave three per cent. below the requirements of a health-giving atmosphere, with, of course, a proportionate increase of nitrogen and carbonic acid. By continually breathing such an atmosphere affections of the lungs ensue, and the miners' "disease of the chest" carries off its victims by scores annually.

The miner himself begins to think the air poisonous and unfit for breathing when, after having enlarged the wick of his candle, it nevertheless flickers and goes out; for a candle will not burn in an atmosphere containing 3 per cent. of carbonic acid with less than 18 per cent. of oxygen. "I have been informed," says Dr. A. Smith, "by Cornish miners that they have worked in places where it was impossible to remain more than ten minutes at a time, for the candles went out, and nearly every man fell down exhausted." Only think of such a frightful state of things, and the damaging effect upon health.

"When the inspired air has the same composition as that which is exhaled, the object of respiration is no longer attained; for the expired air is used up, and cannot a second time perform the same function in the lungs. The venous blood is no longer changed into arterial, and difficulty of breathing and suffocation soon follow, just as if the mouth and nose had been closed." † The influence of a free supply of good air may be, perhaps, more readily appreciated when it is understood that the lungs constantly require, and, indeed, receive, on an average, 20 cubic inches of fresh air at each inspiration, that is, about 400 cubic inches per minute, during which time as much as 150 ounces of blood are propelled through them. The daily requirements of the human machine are about 38 hogsheads of air and about 25 hogsheads of blood. Another most important fact must be taken into consideration, that the blood as it circulates has in itself no power of selection, but absorbs poisonous matters of any kind if they happen to be present in the atmosphere.

Nor must we overlook another source of evil, which is to be found in the organic matters, &c., floating about in mines. If, as you approach the entrance of a pit, a gleam of sunlight happen to play across it, you will at once perceive an immense quantity of solid matters issuing forth in an endless stream. The impure air of the mine is loaded with these solid particles, which, when caught aad submitted to microscopic examination, are found to consist of fine particles of coal, crystalline bodies, filaments of organic matters, &c., and in iron mines in addition fine portions of ores, the solid products from gunpowder explosions, arsenic in small quantities, saltpetre and sulphides of various metals. Now when I tell you that with a given amount of inspired air the miner takes into his lungs from 60 to 80 grains of such impurities during each day's work, it will be readily understood that these matters must, in a short time, exert a very injurious effect upon the lungs as well as the other organs of his body. The entrance of all small particles might easily be prevented by the use of a simple respirator, made of a layer of cotton wool placed between fine wire gauze; this could be made for a few pence.

The liberation of many of the solid products enumerated above, might be prevented by the substitution of gun-cotton for gunpowder, and by using Professor Abel's fuse instead of the present dangerous, clumsy, and careless mode of firing the charge for blasting, no danger to life or limb need occur. The Abel fuse is fired by a simple form of magneto-electric machine, and the time of firing can be regulated with the greatest precision, and the distance from the charge be increased at pleasure.

Until the beginning of the present century, the only means of ascertaining the accumulation of fire-damp to a dangerous extent was at the almost certain risk of igniting the whole; while the dim light afforded by the steel-mill was the only one with which a dangerous atmosphere could be approached; and even with this, there was the actual danger of the sparks given off inflaming the gas. In 1812, the insufficiency of the then existing arrangements was made painfully apparent by the Felling Colliery explosion; the fact of a pit judiciously worked, and, as was supposed, adequately ventilated, being subjected to so extensive a calamity as to cause the loss of three-fourths of the large staff of workmen employed in it, led many to make the most earnest endeavours to devise some remedy for the evil. The first recorded invention in this direction was a lamp devised by Dr. Clanny, capable of being burnt in an explosive atmosphere. This consisted of an arrangement for blowing the air to support combustion through a column of water, and for permitting the escape of the heated air through the same medium. The lamp which is now called the Clanny Lamp bears very little resemblance to the original, it is somewhat like the old Geordie. I have one on the table, found after the Gethin explosion. At length Sir Humphrey Davy turned his attention to the subject, and found, while pursuing his remarkable "Researches on Flame," which after due time led to the invention of the Safety Lamp, that no explosion could be produced in a mixture of air and fire-damp passing through narrow tubes, owing to the cooling influence exerted by the tube upon the gas, and that the narrower the tube the shorter was the length required to produce this protective effect. Hemming's safety tube for the oxyhydrogen blowpipe depends for its efficacy upon the cooling influence which the metallic tubes or channels exert upon the burning jet. The heat of the flame is in this way prevented from passing backwards, and causing the explosion of the mixed gases in the reservoir.

Flame is well understood to be (in all ordinary cases) a luminous envelope, which forms a limiting surface between the unburned combustible within and the supporter of combustion without. It is important to impress this fact upon miners—that on the approach of the flame from an explosion, which can sometimes be

* Dr. Angus Smith's "Reports on the Air of Mines."

† Liebig's "Letters on Chemistry."

seen to come from a distant point, they might, by instantly lying down in the centre of the tramway, allow the flame to pass over them, then by quickly recovering their position avoid the choke-damp, and thus save their lives. This, I believe, has been more than once the way in which many a miner has managed to save his own life amid almost universal destruction.

It is well known in the laboratory, that, by using wire gauze, we may easily cut off the upper part of a flame, the unburned gases being reduced in temperature below the point required for ignition; and if we employ a piece of gauze with about 400 meshes to the square inch, the conducting power of the metal is sufficient to cool the flame below the point of ignition, even though the wire itself may become red-hot. In a similar manner the gas above the gauze may be kindled, and the flame will not pass through to that below.

Sir H. Davy, in the construction of his miner's lamp, beautifully adapted these principles, so that the miner might carry on his work without allowing the flame to come in contact with the surrounding atmosphere. The wire gauze used in the construction of these lamps contains from 700 to 800 meshes in the square inch. In a strong current of air, the heated gas may be blown through even this fine gauze, and thus suddenly cause an explosion; but, of course, such an occurrence can be easily guarded against. The lamp itself is merely an ordinary oil lamp, inclosed within a cylinder of fine wire gauze; it is provided with a double top, and a crooked wire, which passes up tightly through a tube traversing the body of the lamp, for the purpose of trimming the wick without the necessity of removing the wire case. When such a lamp is introduced into an explosive mixture, the flame is seen gradually to enlarge as the proportion of the gas increases, until at length it fills the entire gauze cylinder; when the gas is greatly in excess, the lamp is entirely extinguished; if quickly removed from the mixture while the cylinder appears full of flame, the wick is rekindled. Whenever this pale, enlarged flame is seen, the miner should withdraw; for though no explosion may be looked for while the gauze is sound, yet at a high temperature the metal rapidly oxidizes, and then easily breaks into holes. In such a case, a single aperture of sufficient size determines an explosion.

The means employed for detecting fire-damp are few and simple. The viewer or his deputy is bound to inspect all the workings before the men are allowed to begin work, and with his Davy lamp determines whether it is safe for the men to use naked lights or the safety lamp. In the latter case, the lamps are supposed to be securely locked; but even this regulation is set at defiance, for the men will at times suck the flame through the wire gauze to light their pipes, and by this selfish act they hazard their own lives, as well as those of their fellow-workmen.

In the viewer's trial, he reduces the flame of his lamp to about the size of a horse-bean, and then slowly raises it into the suspected atmosphere, carefully watching the flame. If there be three per cent., a pale blue cap overhangs the flame; if more than five, but less than seven per cent., the flame elongates in proportion to the quantity; if more than seven, but less than fifteen per cent., the lamp explodes (that is, the gas within the gauze) with less or greater violence; if the mixture contains more than fifteen or sixteen per cent. of fire-damp, it burns quietly; and if more than this, it is unable to support combustion, and the lamp is extinguished. In former times these trials were made with a naked candle, and an explosion commonly told of the presence of the gas; even with the Davy lamp, in competent hands, these trials are not actually safe, as is evidenced by the report of Mr. J. J. Atkinson, of the Newbottle Colliery, wherein he gives two instances of explosions through the gauze of Davy lamps, which were found in perfect condition after the accidents. These were common Davy lamps. Many important precautions are required before using a new Davy lamp. The wire, at the time of its being drawn out, is lubricated with oil to enable it to pass through the steel die which regulates its size, and it is found that it retains on its surface a thin film of this oil, even after it has been woven into gauze. If, therefore, a new lamp is taken into an explosive mixture, the ignition and combustion of that mixture heats the gauze to redness, and the oil volatilises and ignites the fire-damp outside the lamp.

To fully comprehend, then, the advantages and disadvantages of the Davy lamp, we will take them *seriatim* :—

1. The fire-damp will explode through the gauze of a perfectly constructed lamp.

2. The lamp goes out if taken into a very impure atmosphere, and this happens in cases where light is absolutely necessary to the saving of life, or where there are urgent works to be conducted in an atmosphere which will support life for a short time, but where the Davy lamp will not burn. On this ground it is to be hoped that a means will be found of using the electric light in some way or other, either in Dumas' form or in that of the diver's lamp.

3. The Davy lamp may be, and indeed, as we have already seen, often is, opened by the miner, even after it has been locked by the viewer, either to light his pipe, or to obtain more light, for the gauze sadly obstructs light.

4. It may easily be extinguished by a current of air, or by a drop of water falling from the roof of the gallery.

5. If the lamp be tilted on one side, the oil is liable to run over the gauze; and in such a case, as not unfrequently happens, it causes an explosion.

We must not, however, lose sight of the fact that in spite of the disadvantages just enumerated, the Davy lamp has proved of very great value to the miner. Many changes and alterations have been from time to time proposed for the purpose of overcoming some of the objections above mentioned, but hitherto, all the proposed improvements have ended in disappointment and failure.

The Stephenson lamp, or, as it is popularly termed, the "Geordie," has its own peculiar advantages and disadvantages, which have been variously estimated by those who have used it. Its chief value is, that it is so constructed that the moment an explosive gas reaches the point of the flame it is extinguished, so that the miner cannot work on until the gauze becomes red hot. The flame is protected by a glass cylinder within the gauze, but should this be broken by accident, as sometimes happens, and the men continue to work on, they have rather less protection than with the Davy. The workmen object to the "Geordie" because of its greater liability to accident; when accidentally extinguished, they must go in search of the foreman, or make their way to the pit's mouth, which often occasions the loss of a day's work, besides having their "draw" to pay. This circumstance alone determines the choice of the Davy lamp, and partially explains the reason why men are so often found, contrary to the rules of the pit, in possession of a false key to open the lamp to relight it, and not to enable them to enjoy the luxury of a pipe.

The Dumas lamp consists of a battery, an induction coil, and a vacuum tube, and utilises the light produced by the passage of an electric current through a glass tube. It produces a slightly magnified glowworm light, just sufficient to guide the miner through the darkness, but barely enough to see to work by. The tube is made of uranium glass hermetically sealed in vacuo, which is protected by a thicker exterior tube, to which is attached a semi-cylindrical reflector to concentrate the light. If the light of such a lamp can in any way be utilised in mines, it may prove of value, for it could not be extinguished either by gas or by a sudden irruption of water, as it shows equally well under water. The batteries may also be made of use for other purposes, such as exploding gun-cotton or gunpowder for blasting, &c. I believe, however, that practical men, and those who

have tried the lamp, despair of bringing it into general use. A very serious drawback to its general employment is its expensive and cumbrous form, and after all, the light it gives out is very inferior to either the Davy or Stephenson lamp. Danger is, however, reduced to a minimum, because, in the event of fracture of the glass tube, the vacuum is destroyed, the air rushes in, and the lamp is immediately extinguished.

We may then conclude that all mere mechanical contrivances for shutting off the gas from the source of illumination have proved failures, and altogether inadequate to grapple with the difficulties to be dealt with in mines; and therefore science has been driven to look in another direction for the means of lessening the dangers attendant upon mining. For this purpose Mr. G. F. Ansell, of the Royal Mint, lately invented a most sensitive "Fire-damp indicator," whereby he is able to detect the smallest appreciable quantity of fire-damp in a mine. This is undoubtedly a step in the right direction.

As in the case of the safety lamp, Ansell's fire-damp indicator is the practical application of a natural law, that of diffusion. Dr. Priestley first noticed the phenomenon which has since been more fully developed by Berthollet and Dobereiner in 1825, and by Graham still more recently, who evidently sought out and explained the law which governs the diffusion of gases, and which law may be thus popularly explained:—When two different gases, as atmospheric air and fire-damp, for example, are brought into contact with each other, they have a tendency to mix; and while this mixing is taking place, the atoms of each gas travel at a certain speed peculiar to that gas, which speed remains the same under all circumstances. Another peculiarity is, that the speed of a gas remains the same whether it is passing into space or intermixing with another gas, and whether it passes through a porous substance or an open tube. Mr. Ansell practically applies these facts to the detection of fire-damp; and since his indicator enables him to ascertain the exact percentage of this or other deleterious gases, the application is of the very highest importance and value, not only for coal and metal mines, but wherever subterranean works of any kind have to be carried on, for it as readily indicates the presence of the deadly choke-damp if in a poisonous amount. It is also capable of being made equally useful for the detection of coal-gas in houses and large buildings, as theatres, railway tunnels, and the proposed subways in our streets; or in the holds of ships, where foul air or fire-damp often collects. In short, in various other branches of mechanical art, it is capable of being turned to most valuable account for the preservation of human life.

Many of the phenomena attendant upon the mixture of gases are so extremely interesting, that we must not pass them by without a few special observations; and for the better elucidation of our subject it will be as well that we should briefly notice some of the more important. The laws which govern the movements of mixed gases are of a totally different character to those which operate upon mixed fluids. The latter are invariably arranged in strata, or layers as it were, and in exact accordance with their specific gravities, the lightest finding its way to the surface, and the heaviest sinking to the bottom of the vessel in which they are placed. From this fact it is concluded that no chemical action is exerted in order to effect their incorporation, and that by the force of gravity alone each liquid assumes its relative position. With respect to gases, which also vary in density to a very considerable extent, no such separation takes place. If chlorine and hydrogen, the specific gravity of the former being thirty-six times as great as that of the latter, be placed in two distant vessels, and be allowed to communicate by means of a long tube, the hydrogen, or the lighter gas, being placed uppermost, the heavier chlorine will, in the course of a few hours, find its way into the upper jar, as may be seen by its green colour, whilst the hydrogen will pass downwards into the lower jar, and ultimately the two gases will be found to be equally intermixed throughout, and when once mixed, there is no disposition to separate again, however long they may remain at rest together. The rapidity with which this diffusion occurs varies with the specific gravity of the gases; and, contrary to what might be generally supposed, the more widely the two gases differ in density, the more rapid is the process of intermixture. In the earliest investigations into this very interesting subject, a very simple apparatus was employed, which consisted of a plain cylindrical glass tube, ten or twelve inches in length, and one inch in diameter, closed at one end by a porous plate of plaster of Paris, graphite, or any dry porus substance; it was then ready for use. The term *diffusiometer* has since been applied to it.

Mr. Ansell has a ready and simple mode of showing the action of the diffusiometer. He takes the tube and fills it with ordinary coal-gas; this he supports in a jar of water, when the water immediately begins to rise in the tube, and will continue to do so in opposition to gravity, until in the course of a few minutes it stands three or four inches higher inside the tube than the surface of the fluid in the outer vessel, in consequence of the coal-gas passing out through the pores of the plaster of Paris much more rapidly than air can pass in. In the case where different gases are mixed, and then introduced into the diffusion tube, each preserves the rate of diffusion peculiar to itself. If, for instance, hydrogen and carbonic acid be mixed and placed in the diffusion tube, the hydrogen passes out with much greater rapidity than the carbonic acid, and a partial mechanical separation of two gases differing in density may thus be effected. The rate of diffusion is, as might be expected, accelerated by a rise of temperature; for by heat all gases are rendered specifically lighter.

The rapid passage of gas through the minute pores of the plates is a remarkable phenomenon, and one which is thought to fully demonstrate the molecular theory of bodies; but still more remarkable, the infinitesimal particles of gaseous bodies find their way quite as rapidly through such substances as india-rubber, etc., which neither microscopical nor chemical examination had heretofore shown to be porous. Upon submitting the very finest pellicle of india-rubber to the highest powers of the microscope, it presents a perfectly homogeneous appearance, and no pressure, however carefully applied, will force a fluid through its minute pores; nevertheless, gases pass readily through it. And if there is one fact in connection with this discovery of Mr. Ansell's possessing greater interest for chemists than another, it is that heavy carbonic acid as readily diffuses through this substance as the lighter gases; and in an equal degree produces expansion of the india-rubber. He is engaged in the investigation of this very remarkable fact, with a view to discover the law on which it is based.

The process of diffusion is one which is continually going on and playing an important part in the atmosphere which surrounds us, as well as in the various departments of nature. Accumulations of gases unfitted for the support of animal and vegetable life, are by its means silently and speedily dispersed; even respiration itself could not be long maintained were it not for the process of diffusion, which rapidly displaces that air which has been rendered unfit for the support of life, and at the same time draws downwards a fresh supply of purer and specifically lighter air.

Enough has now been said to convey a clear idea of the singularly beautiful phenomenon of the diffusion of gases, and light the way to a more exact comprehension of Mr. Ansell's fire-damp and choke-damp indicator.

It was represented to this gentleman that fire-damp would become comparatively harmless if its presence in the mine could be made known by a signal in the manager's room above ground; the essential condition being, that such means should be entirely self-acting. In September, 1862, Mr. Ansell visited some coal-mines

in the Midland district, for the purpose of ascertaining the conditions to be met, and was conducted to a portion of a pit known to be pretty tolerably charged with an explosive mixture. The gas caused a peculiarly helpless feeling to come over him, and "his head had an extraordinary light feeling, and it appeared to be filled with fire-damp," so much so, that it occurred to him that if his head had been made of india-rubber, he could have brought away some of the gas. On his return home, an india-rubber balloon his child was playing with attracted his attention, and he thought he might turn this plaything to account; this thought was elaborated, and associated with a law just spoken of, and then uppermost in his mind—namely, that of osmose, or diffusion.

Mr. Ansell's first experiments with this india-rubber balloon were so near perfection, that all subsequent improvements in the form of the apparatus partake more of the nature of scientific refinements than of any positive departure from his original conception.

It will only be necessary to mention here that Mr. Ansell applies the principle of the diffusion of gases to produce sufficient force to release a detent, and set an alarum in action. An inflated india-rubber ball, prevented from expanding laterally, or a bent tube of mercury, enlarged at one end, and closed with a porous cover, is all the apparatus that is needed for the purpose. If the ball or tube be exposed to any kind of gas, that gas will pass through the porous structure; and mixing with the air confined in the ball, or under the porous cover, will increase its bulk. Thus the ball will receive a vertical expansion, and may be used to set the detent of an alarum apparatus in action; or mercury, being forced up the open limb of a bent tube, may be used as an indicator, or an electrical conductor, to convey a telegraphic signal to the mouth of a pit, or the manager's office, or any other convenient place.

Mr. Short, of the firm of Marratt and Short, of King William-street, has, under Mr. Ansell's direction, succeeded in producing a convenient and cheap adaptation of this beautiful invention, which consists of a tube with a porous tile, an alarm bell, and a small permanent galvanic battery, inclosed in a case. The action of this little instrument is so rapid, that the alarm is given in less than five seconds from the time of an irruption of gas. The apparatus also possesses the advantage of portability; the miner is enabled to move it with him to any part of the workings. The instrument above spoken of is intended to give warning alone; but if it be desired for the information of viewers, inspectors, owners, and others, to ascertain the amount per cent. of either fire-damp or choke-damp present in the air of mines, Mr. Ansell varies the form of his apparatus, the most convenient for the purpose being that of a small aneroid barometer for the waistcoat pocket.

The dial-plate of the aneroid is graduated with the ordinary barometrical scale, which gives it the advantage of being used as a barometer when not wanted as an "indicator;" a small valve is the only addition necessary, and this when opened converts the instrument into a barometer, and when closed into a fire-damp indicator. Its indications are uniform and unvarying, giving for 100 per cent. of gas 1·68 inches rise on the barometrical scale, and for 10 per cent. 0·130 inch. The presence of choke-damp is readily determined by this instrument, as the index-hand moves in an opposite direction when plunged into a mixture containing the smallest percentage of carbonic acid.

The action of the instrument, from its simplicity of construction, is readily understood. When placed in an atmosphere containing fire-damp, the hand travels over the face of the dial because the diffusion of the fire-damp into the chamber of the aneroid barometer causes an increased volume, which, being forced to occupy a fixed space, makes pressure on the partly exhausted chamber within that space, and thus causes the hand to move over the face of the dial, indicating unfailingly the amount per cent. of explosive gas. The following results have been obtained in the presence of experienced miners by Ansell's aneroid indicator:—

The aneroid indicated 1·5 per cent. of fire-damp. The Davy lamp gave no indication.

The aneroid indicated 3·0 per cent. of fire-damp. The gas could be detected by the Davy lamp, which gave a small blue flame.

The aneroid indicated 6·0 per cent. The Davy lamp did not explode, but its flame elongated greatly.

The aneroid indicated 8·0 per cent. The Davy lamp exploded feebly.

The aneroid indicated 10·0 per cent. The Davy lamp exploded fiercely.

Very lately Mr. Ansell attended in one of the committee-rooms of the House of Lords for the purpose of exhibiting his invention, and so satisfied of its value were all who witnessed the experiments, that Sir George Grey thought fit to direct an inquiry into its merits. Indeed, it is impossible for anyone to see this refined scientific application and not be struck with its practicability and utility for the purpose of indicating the presence of fire-damp in mines before it becomes dangerous from accumulation. Mr. Robert Hunt speaks in the highest terms of the value of this beautiful instrument. He is, I believe, perfectly satisfied of its utility, and I trust is here to night to speak of its merits and demerits, if he thinks it has any. But so confident do I feel of its practicability and usefulness that I am sure, if mine-owners will but give it a fair trial for twelve months, they will have the satisfaction of seeing "accidents from explosions" almost, if not entirely, abolished from the annual reports.

DISCUSSION.

Mr. Robert Hunt, F.R.S., said he could not but express his gratification at the able manner in which Mr. Hogg had brought forward this subject. When it was remembered that at the present time we were raising little short of one hundred million tons of coals annually, involving the sacrifice of a thousand lives every year, it was a matter which came home to the heart of every one, and consequently every invention which might tend to lessen, even in a small degree, this fearful destruction of life, merited our serious attention. With regard to Mr. Ansell's invention, he could not but say he regarded it as one of the most beautiful applications of science that he had ever seen, and one which appeared likely to be most useful. They must not, however, while they admired this beautiful instrument, expect too much from it at once. They had to contend with the prejudices and existing habits of uneducated men. He had, within the last few weeks, visited all the great colliery centres of the United Kingdom, in each of which he had conversed with the colliery inspectors and viewers, on the advantages and disadvantages of Mr. Ansell's invention. A great many spoke highly in its praise, whilst others stated some objections to it. Some of them told him that with the safety lamp they could detect fire-damp as readily and accurately as with Mr. Ansell's aneroid instrument. It was certainly the fact that a practised eye could determine, with a great amount of accuracy, by the condition of the flame in the safety-lamp, the quantity of fire-damp that was present; but there was often carelessness, induced by habit and want of education, that led the men to disregard these indications; and when they found that the lengthened flame of the lamp only showed a small amount of fire-damp, they were satisfied it was not sufficient to occasion an explosion, and took no precautions. It was found that constant association with danger, after a time, produced recklessness, and the same thing might occur even if Mr. Ansell's instrument was in use. He remembered the first time he saw fire-damp was under circumstances which rather terrified him. He was in a mine in which naked candles were employed, and, having expressed a wish to see a part of the mine in which fire-

damp was known to exist, he was conducted to one of the galleries in the roof of which he was told there was fire-damp. In proof of that, his companion gradually raised his candle towards the roof, the flame becoming elongated as he did so, and the man informed him that if it were raised six inches higher there would be an explosion. It would be satisfactory to state that a few weeks since he attended at a trade meeting of coal owners in the town of Leeds, and having one of Mr. Ansell's instruments with him he explained it to several coal proprietors, one and all of whom expressed a desire to possess it, so satisfied were they of its usefulness and applicability. Some of them told him they were satisfied that every colliery viewer and manager would soon carry one of these instruments as he now carried his watch. He did not at present think they could expect any very general practical application of the other form of indicator which Mr. Ansell had introduced, except in some of the most fiery districts, as it involved a somewhat complicated system of electrical communication throughout the mine. He could have wished that Mr. Hogg, in the paper he had brought before them, had not mixed up the metalliferous mines and the coal mines. The circumstances of the two were so entirely different, that it was a pity they should be in any way confused together. The employment of the collier was healthy in the extreme; a more healthy class of men was not to be found among the working population of the United Kingdom. On the other hand, a more unhealthy set of men than the metalliferous miners could not be found. The miners of Cornwall were mentioned as especial examples of the injurious effects of working in bad air. The mines of Cumberland, Durham, Northumberland, North Wales, and Cardiganshire, were as injurious as the deeper mines of Cornwall, and yielded more carbonic acid. With regard to collieries, the ventilation was generally as satisfactory as could be expected, looking at the difficulties with which the subject was surrounded. The quantity of air constantly passing through the mines was generally sufficient to sweep out the fire-damp, but still they were and ever must be liable to sudden outbursts of fire-damp, and these might be detected by the miner by the aid of Mr. Ansell's instrument. The ventilation of metalliferous mines in nearly all cases was that which was called "natural." The ventilation in the Cornish mines had been spoken of by the commissioners appointed to examine into the question as of the worst description, and the analyses of Dr. Angus Smith and others had shown that the air was not in a satisfactory condition. It must, however, be remembered that the main parts of a metalliferous mine were not in this deadly state; but where the men were driving levels or working at the close ends there were accumulations of organic matters and of carbonic acid gas which were exceedingly injurious. The application of the plans adopted in the collieries to metalliferous mines had been spoken of, but he was not himself prepared to believe that the one condition of ventilation was applicable to the other, as the conditions of the two descriptions of mines were totally different. In ventilating collieries they were dealing with a series of galleries worked upon a horizontal plane, whilst in a metalliferous mine the galleries were worked vertically, and thus the means of ventilation which were applicable to the one condition were not applicable to the other. Doubts had been thrown out in the paper as to the value of the safety-lamp, but his own belief was that a well-constructed safety-lamp was as perfect an instrument as could be made by human hands; and if the modified Davy lamp were placed in the hands of the men he did not believe it was possible to supply colliery miners with a safer instrument. That the men were reckless there was no question. He had himself seen them suck the flame through the wire gauze to light their pipes, and with the point of the pick endeavour to open the wire so as to obtain a better light to read by. They had for the most part to deal with an ignorant, uneducated class of men; and while they were producing for them a series of ingenious mechanical appliances—while they were studying a series of delicate scientific applications—they were forgetting one essential—the education of those men. It was no more use giving an ignorant man such an instrument as this than giving a watch to a baby. The education of these men would be a work of time, but the time would be well spent in giving them the right kind of education, which would ultimately teach them the best means of protecting themselves.

Mr. P. H. Holland agreed with much that had been said by Mr. Hunt, but he must take exception to the remarks made with respect to the Commission, of which he (Mr. Holland) was a member. Mr. Hunt implied that the commissioners came to the conclusion that metal mines and coal mines could be ventilated in the same way. He could say for himself, and he believed for every other member of that commission, that no such absurd idea was ever entertained by them. They only insisted that a sufficient quantity of air should be supplied to each description of mine. The means by which it was supplied would be as different as the two cases were different, the one being worked on a vertical plane, and the other on a horizontal plane. Another point to which he took exception was attributing a large portion of the diseases among metal miners to the effects of carbonic acid gas. He believed the evil effects of that gas to be overrated; it was only to a small extent that miners were injuriously affected by it. It was not so much the bad air of the mine itself as the confinement of gunpowder smoke, animal effluvia, candle fumes, and dust, which should be carried away by ventilation. Another way in which metal miners suffered was, that, often working below in great heat, a sudden chill was occasioned when they came into the upper atmosphere. The catching cold after working in the hot, close mine, with the frame exhausted by foul air, was one of the great causes of the diseases from which the miner suffered. The author of the paper had made a slight error in representing him (Mr. Holland) as having been employed to investigate the cause of the Lundhill explosion, for his commission was only to effect the removal of the bodies with the least danger to those employed. In the next place Mr. Hogg entertained the impression that the great attention which had been paid to this subject had produced very little fruit, but he (Mr. Holland) was of a contrary opinion. The new legislation had done much good. There was a difference of opinion as to the extent to which the number of miners had increased in this country, but they knew it was very considerable. The number of deaths from accidents from all causes, which used to be 1,000 per annum, was now only 957. That appeared to be a small diminution; but when it was recollected how large an increase had taken place in the number of miners (which some estimated at 30 per cent.), it reduced the relative amount of accidents very much indeed. This was due, in his opinion, partly to the fact that the new legislation threw the responsibility more definitely upon the owners of the mines of guarding against accidents. Thus the number of deaths from explosions had been diminished from 114 per 100,000 to 50; those from shaft accidents, from 100 to 54; those from falls of coal or roof, from 176 to 148; and those from miscellaneous accidents, from 78 to 71. He did not in this return include the Hartley colliery accident, which resulted in 204 deaths; by this the miscellaneous deaths would be largely increased; but the occurrence was so exceptional in itself that it would not be fair to take it into account in taking an average of a small number of years. The two large classes of accidents against which the owners had to take precautions had diminished to about half, whereas the others had not diminished so much. That was a strong indication that the principle he advocated in 1859, that the masters should be made responsible for the precautions to be observed, was a

true principle. But that was not all. These accidents were, however, still a great deal too frequent. He did not hope to prevent explosions in mines altogether; that would be Utopian, but the number of deaths might be still further diminished. The great cause of explosions was the sudden accumulation of gas; and such an accumulation as would involve a loss of life could hardly take place in a short time; if, therefore, they could have indications of the state of the mine at frequent short intervals, they might have comparative security against large explosions. What better plan could be adopted then putting the mine itself in communication with the office of the manager? This was done by Mr. Ansell's instrument. He confessed himself a convert to this invention. His impression at first was that it was a very beautiful invention, but one of very little practical use, because the safety-lamp would indicate the state of the mine; but there was this difference, the safety-lamp only indicated this at the spot itself, whilst this instrument indicated it at the manager's office, and this would act as a material check upon the men. One of the most common causes of accidents was the neglect of ordinary precaution in the opening or closing of a door within the mine. This would arise much less frequently if the master had the means of instantly detecting such a neglect of duty. Having spoken in high terms of Mr. Ansell's instruments, Mr. Holland urged that proper trials of them should be made in all our mines; and he could not imagine that practical men would offer any objections to them. They had no right to expose their men to danger in respect of explosions through obstinate rejection of proper precautions. If this invention was really, as he believed, of the greatest value, colliery owners should not be merely asked to adopt it, but should be compelled to do so.

Mr. J. A. Phillips observed that the last speaker had implied that practical men were prejudiced, and unwilling to adopt scientific improvements, but it must be remembered that practical men were fully aware that, generally speaking, scientific men were eminently unpractical, and, consequently, it was not to be wondered at if they (the practical men) sometimes hesitated in adopting the suggestions of men of science. With regard to Mr. Ansell's instruments, as indicating imperfect ventilation, it must be remembered that although each individual instrument would doubtless give the alarm in case of an accumulation of gas in the locality in which it was situated, yet the state of ventilation would differ so essentially in the different portions of a mine, as to necessitate the introduction of a great number of instruments along the different galleries and workings. To each of these separate wires would have to be attached, communicating with different instruments in the manager's office, necessarily entailing much expense and complication. He therefore doubted if the proposed system would be found so easy of practical application as the gentleman who had last spoken appeared to anticipate.

Mr. Hunt begged to be allowed to say that Mr. Holland left an impression on the minds of those who had listened to him that the proprietors of collieries were not sufficiently careful either of their men or their property. He inferred that they required to be compelled to do this thing and that thing, as though they were not themselves anxious to protect the lives of their men. He felt bound to say that his experience led him to the conclusion that throughout the United Kingdom there was no class of employers who were more desirous of protecting their men than were the colliery proprietors, and if we would only suggest to them—not insist upon it—the introduction of an appliance for the benefit of their men and the security of their property, he believed they would at once adopt it.

Mr. Holland remarked that since the ventilation of the mines and the covering of the cages had been insisted upon by the Legislature the accidents of a certain class had diminished by one-half.

Mr. Varley said, fifty years ago, in this room, a very long discussion took place amongst those interested in coal mines as to the means of ventilation. He thought the plan then advocated, which he called the air syphon system, produced the most complete and effective ventilation.

Mr. R. H. C. Wilson inquired whether Mr. Ansell's aneroid indicator was graduated to a uniform standard, so that any number of instruments would give precisely similar indications.

Mr. Ansell replied that this was the case.

Mr. Benjamin Shaw, referring to the invention of a safety cage for miners to prevent accidents from the breaking of the rope or chain in descending the shaft, inquired whether any sufficient reason was known for its not being generally employed. Having lately visited the Clay Cross collieries, he could bear testimony to the measures which were taken by that company for providing for the educational and social wants of the large community of people employed in those collieries; especial attention was there paid to the education of the children of the colliers.

The Chairman said he was sure all present would agree that Mr. Hogg deserved their best thanks for the interesting and able paper he had read that evening. He thought if the instrument invented by Mr. Ansell were brought into practical use, its value would soon be appreciated. If the public felt some degree of certainty that the fearful accidents which were now so frequently occurring might be greatly mitigated or wholly prevented by an instrument like this, they would feel that those who were held responsible for those accidents, and who neglected to provide themselves with so simple an apparatus, were highly culpable. He thought the most practical way of bringing an invention of this kind into general use, was to make either the owner or the agent responsible for any accidents that its use might have prevented. No matter what Acts of Parliament were passed, or what rules were laid down, they would be all treated as nothing until public opinion was brought to bear upon mine owners, to compel them to adopt this or any other useful invention for saving life in mines. He thought they owed much to Mr. Hogg for having brought this subject so lucidly before them, and for introducing to their notice Mr. Ansell's valuable instrument.

The vote of thanks having been passed,

Mr. Hogg expressed his acknowledgments for the manner in which his paper had been received. He was aware that a great variety of topics were embraced in it, and for that reason he was unable to go so fully into the merits of Mr. Ansell's invention as he could have desired. The aneroid indicators were manufactured to a uniform scale, and gave uniform indications. With regard to his having mixed up the subjects of coal and metal mines, this had been forced upon him by the form in which the reports of the inspectors of mines were drawn up, in which he found these subjects so combined that he was unable to separate them. That the education of the mining population, and more especially of their children, was receiving a greater amount of attention there could be no question; and children under twelve years of age were not allowed to be employed in mines; but in spite of all the efforts made, he agreed with Mr. Holland that there had not been so much done as ought to be done. He did not place much stress upon the diminution of the ratio of deaths as that gentleman did, regard being had to the increased number employed, because he found that the decrease of accidents was principally confined to the northern coal mines, and did not affect the metal mines of the south. Looking to the reports of the inspectors, he believed the safety cage alluded to by Mr. Shaw had been very much adopted. As to the necessity for a great multiplicity of Mr. Ansell's indicators, which had been objected to by Mr. Phillips, he apprehended that one instrument would be sufficient for the protection of each working, and the wires being placed in connection with the signalling apparatus,

would convey the warning to the manager's office above ground. He thought that no confusion need be apprehended in such an arrangement.

Mr. G. F. Ansell has forwarded the following description of the different forms of his apparatus referred to by Mr. Hogg:—The apparatus is of three kinds. The first consists of a diffusiometer, an electric alarum, and a small galvanic battery, the whole being arranged under a small stand, of sufficient portability for the miner to carry with him into the heading where he is at work, and upon a sudden irruption of fire-damp the alarum is rung instantaneously. Its action may be explained in the following manner:—The diffusiometer consists of a bent tube in the form of the letter U, having at one end a cup or chamber, the surface of which is enclosed by a piece of porous tile. This tube is partially filled with mercury. When the fire-damp surrounds it, diffusion of the gas takes place through the porous tile, compressing the volume of air within the cup, and thereby forcing the mercury downwards, which rises in a corresponding manner in the opposite side of the tube; this is made to form contact with one of the terminal poles of the battery, and the alarm is given. By proper adjustment it can be set to indicate within five seconds after the irruption of gas. The second form of instrument is for indicating gradual accumulation; it consists of an inflated india-rubber ball, which is fixed in a frame. Diffusion takes place through the surface of the ball, causing it to expand. This force is applied by a mechanical arrangement to complete the circuit of a battery, and by means of a telegraphic wire it will indicate at the mouth of the pit where the air of that particular part of the mine is explosive. These instruments could be placed in different parts of the mine, and by a simple system of telegraphy a perfect knowledge of the state of the air would be had by those above ground; and in the case of a gradual accumulation taking place in the night during the absence of the miners, the affected part of the mine would be indicated at the mouth of the pit. The third arrangement is for indicating the presence of fire-damp and measuring its quantity. It is an adaptation of the aneroid barometer, and is extremely portable, being little larger than an ordinary watch. The instrument is graduated to the ordinary barometrical scale, and can be used as a barometer. When not required as a fire-damp indicator a small valve is attached, which, being open, admits the atmosphere, and the instrument acts as a barometer; but when closed, the admission of gas must be through a porous tile, which causes compression (as before explained), and the indication is given by the hand upon the dial. The indications are unvarying, 100 per cent. of fire-damp being indicated by 1·680 inches of the barometrical scale, and 10 per cent. by 0·130 inches. It will also determine the amount of carbonic acid or choke-damp, the hand moving in the opposite direction to that for fire-damp.

Mr. R. H. C. Wilson writes:—"I found, on examining Mr. Ansell's aneroid indicator after the meeting, that it is really a pocket aneroid, the only difference in construction being that the back of the outside metal case is cut out, and a back of plaster of Paris is put in its place. It is really wonderful that so slight an alteration should cause the instrument to act independently of atmospheric pressure. It appears that a variation in the aneroid of one-tenth shows danger; the range of the instrument, therefore, between safety and danger, is very small indeed, and it would be very desirable if it could be made much opener in the scale."

Proceedings of Institutions.

South-Eastern Railway Mechanics' Institution.—The report for the half-year ending 31st March last (being the thirty-seventh), congratulates the members on the highly-satisfactory position of the Institution at the present time. There are now 280 members of the Institution, which is an increase of 45 over the corresponding period of last year. Eighteen volumes have been purchased for the library during the half-year. The library now contains 1,438 volumes, and two-thirds of them have been in circulation during the half-year. The only alteration in the supply of papers to the reading-room has been the addition of the *English Mechanic*, which is published once a week. In consequence of the great number of female members of the Institution, it was considered desirable that they should have a room appropriated to their own exclusive use on the evenings of Tuesday and Saturday, when the books are changed; the Council-room has therefore been placed at their disposal on those evenings, and been supplied with suitable papers and periodicals. This plan seems to be appreciated by the females, as they frequently attend in large numbers. It is in contemplation to form a class next winter, to consist of female members only, for instruction in domestic economy, with the view of preparing them for examination in that subject by the Society of Arts examiners. Classes for instruction in arithmetic, writing, and spelling, French, and vocal music have been carried on very successfully during the whole of the past six months. Upwards of eighty members have been attending these classes. The members have been privileged to attend gratuitously nine lectures in connection with the Ashford Institution; the attendance was remarkably good, the average per lecture being nearly a hundred. The financial statement for the half-year shows that the balance from last half-year was £84 9s. 9d., which was raised, by the receipts of the present half-year, to £130 12s. 5d. There is now a balance in hand of £47 12s. 6d.

FRENCH REPORT ON TRICHINIASIS.

Two members of the French Academy of Medicine, M. Delpech, Professor of Medicine, and M. Reynal, of the Veterinary College of Alfort, have recently returned from Germany, where they investigated this subject, and have made their report to the French Minister of Agriculture. They declare that the disease is everywhere either extinct or dying out; and, moreover, that, with the single exception of the epidemic at Hedersleben, where a concourse of unfortunate circumstances led to the most terrible results, the mortality has been everywhere insignificant. At Zwickau, Seitendorf, and Sommerfel, out of 80 to 86 cases not a single death appears to have occurred.

Amongst other statements in the report are the following:—The existence of trichinæ is exceedingly common in Germany; nothing in the appearance of the living animal nor in its flesh when killed is to be detected either by the naked eye or by means of an ordinary magnifying glass; the microscope alone brings the insects or their eggs into view. No case of trichiniasis, either in man or amongst pigs, is known to have originated in France; wherever this disease exists, the rats, in the horse-slaughterers' yards and in the abattoirs, are found to be infested with trichinæ; examination of these creatures in Paris has not brought to light any trace of these parasites. The writers of the report protest against the terror which trichiniasis has created, and declare that so long as pork is only eaten after being well cooked there is no real danger; moreover, that no trichinæ are ever found in the heart, liver, kidneys, brains, or fat of the pig, so that there should not be the slightest apprehension as regards those parts. The report adopts the view entertained in Germany that a temperature of about 166° Fahrenheit is sufficient to destroy the trichinæ. Thorough salting and hot fumigation, continued during twenty-four hours, they believe to be equally effectual, but cold smoking has no effect. MM. Delpech and Reynal attribute the existence of trichinæ

in pigs to the eating of the flesh of rats, hedgehogs, and other small animals and filth; and propose as remedies the keeping of the pigs in clean well-aired pens or sheds, and the careful preparation of their food when any fear of trichinæ exists; but they express no opinion as to the origin of the trichinæ themselves.

Commerce.

Coffee.—Lascelles, in his work "On the Nature and Cultivation of Coffee," says, the total quantity of coffee consumed in Great Britain in 1864 was about 35,000,000 lbs., of which nearly 30,000,000 lbs. were the produce of India and Ceylon. The total imports to Europe now amount to about 290,000,000 lbs. France alone consumes one-sixth of the total production of the world. In 1809 the exports from Jamaica alone exceeded 83,000,000 lbs., while at present they do not reach 6,000,000 lbs. In British Guiana the exports have fallen from 9,472,000 lbs. to nothing, scarcely sufficient being now grown for consumption in the colony; even in Brazil the exports have decreased, 2,060,819 bags being shipped in 1859, and only 1,495,697 bags in 1864.

Colonies.

Vine Growing in New-South Wales.—The River Murray District appears to be becoming an important vine-growing district, and the large yield of wine has always found a ready sale in Victoria. Several hundreds of acres have been planted by industrial cultivators, and the fruit this season is reported to be small and scarce, with less than the ordinary quantity of saccharine matter, whilst along the coast-line the crop has been luxuriant.

Vine Crop in South Australia.—The probable average yield per acre of full bearing vines was estimated at 400 gallons, and there appeared every reason to anticipate that the quality would be such as to give a high name to the vintage of 1866, and to elevate the character of the wine in the market.

The Forthcoming International Exhibition at Melbourne is being prepared for by the committee appointed to collect suitable examples of the produce of the colony, and there is every reason to believe that in cultivated as well as natural sources of wealth the Perth district will make a considerable show. The minerals and timber, wines, oil, dried fruits and other productions will be exhibited, but in articles of general agriculture the season has been too unpropitious to admit of their sending such samples of wheat, &c., as were exhibited at the London Exhibition of 1862.

Fire at Perth.—A very serious destruction of property has lately been caused by a fire in Perth (Australia), and the fact that much of it might have been saved had there existed any organized means of prevention, has awaked attention to the necessity of a volunteer fire brigade, and a meeting has been held to endeavour to procure a good engine and a proper equipment for the men. Pecuniary assistance will probably be given by government.

Publications Issued.

Annuaire Scientifique for 1866. By M. Dehérain. Paris.—One of the best of the many annuals devoted to the records of scientific progress. M. Dehérain is Professor of Chemistry in the Central School of Architecture and at the Collège Chaptal, and his assistants in the compilation of the annuaire are, M. Amédée Guillemin, Trélat, Worms, Reitop, Duméril, Vignes, Margollé, Zurcher, and Meau de St. Mesmin.

A Defence of the Present Patent-Law. By Michael Henry, Esq. (Published by the Author, 68, Fleet-street.)—This pamphlet sets forth at length the various arguments in favour of the existing patent-law, and concludes by warning persons interested in the industrial and material prosperity of our country against "rashly tampering with a system under which the manufactures and commerce of England have attained a proud position. Let them pause (says the writer) before, by interference with rights of property in invention, they offer grounds of interference with all intellectual and intangible property—the copyright of the designer, artist, publisher, and author—copyright in work, writings, names, and trade marks."

Correspondence.

Dr. Thudichum's Paper.—Sir,—No paper which has been read before the Society can be of more real importance to the public (though repulsive to read) than that with which Dr. Thudichum favoured the members on the 18th inst. The readers of the *Journal* will recollect that in 1857, 1858, an epidemic appeared among the swine in various portions of the American States, which swept them away by thousands. The rapidity with which the disease executed its fatal mission gave rise to the name of "hog cholera." In the Ohio State Agricultural Reports, in my possession, vol. for 1858, the distinguished and learned secretary, Klippart, furnishes a most able paper, by Dr. Wienland, of Cambridge, state of Massachusetts, which may fairly be placed by the side of Dr. Thudichum's, as it most fully substantiates by facts all that that gentleman asserted. In the article referred to, on the "Nature and Organisation of Tapeworms generally," Dr. Wienland proves that measles in the hog (*Cysticercus cellulosæ*) and tape-worm in man (*Taenia solium*) are identical; he arrives at the conclusion in a very scientific and legitimate manner, and it may be well for the agricultural public to be advised of the fact, as well as the steps by which it became known, and the remedies applied, which proved beneficial to the beast, and at length effected an entire cure. This was, to put tar in the bottom of the trough (say a pint in one twelve feet long), and a couple of ounces of flour of sulphur; then one ounce of dissolved saltpetre put with the food into the trough once a day, and chloride of lime sprinkled about the sleeping places. Dr. Wienland concludes that beef is very rarely measly, but it is so sometimes; and though tape-worm in the intestines is certainly troublesome, yet it never seems to be really dangerous, at any rate, to mankind; not so much so as its larva, which evades the skill of the physician when the patient is affected with the hydatids of *Taenia solium*.—I remain, &c., Charles F. Dennet.

Ladbroke-square, April 23, 1866.

MEETINGS FOR THE ENSUING WEEK.

Mon......British Architects, 8.
Actuaries, 7. Mr. W. S. B. Woolhouse, "On the Construction of Tables of Mortality."
Medical, 8. General Clinical Discussion. Cases by the President, Dr. Leared, Dr. Tilbury Fox, and Mr. Walter J. Coulson.
Zoological, 1. Annual Meeting.
Philosophical Club, 6. Annual Meeting.
R. United Service Inst., 8½. Mr. John Elder, "Marine Steam Engines."

Tues ...Civil Engineers, 8. 1. Discussion upon Mr. Manning's Paper, "On the Flow of Water off the Ground." 2. Mr. G. R. Burnell, "On the Water Supply of Paris."
Pathological, 8.
Anthropological, 8.
Geologists' Assoc., 8.
Royal Inst., 2. Annual Meeting.

Wed ...Society of Arts, 8. Mr. George Glover, "On National Standards for Gas Measurement and Gas Meters."
R. Society of Literature, 8½.
R. United Service Inst, 8½. Mr. William Stirling Lacon, "The Loss of Life at Sea. The Remedy."

Thur. ...Royal, 8½.
Antiquaries, 8½.

Linnæan, 8. 1. Mr. George Busk, "Remarks on the Cranial and Dental Characters of the existing species of Hyæna."
2. Mr. G. S. Brady, "Monograph of the recent British Ostracoda."
Chemical, 8. 1. Dr. Gladstone, "Pyrophosphodiamic Acid."
2. Mr. R. Warington, Jun., "Tricalcic Phosphate."
R. Society Club, 6.
Artists and Amateurs, 8.
Royal Inst., 3. Prof. Huxley, F.R.S., "On the Methods and Results of Ethnology."

FRI ......Philological, 8.
Society of Arts, 8. Cantor Lecture. Dr. Crace Calvert, "On the Artificial Production of Aromatic Substances." (Lecture IV.)
Royal Inst., 8. Prof. Abel, F.R.S., "On Recent Progress in the History of proposed Substitutes for Gunpowder."
Archæological Inst., 4.
R. United Service Inst., 3. Dr. Mouat, "The British Soldier in India."

SAT ......Royal Inst., 3. Prof. Huxley, "On the Methods and Results of Ethnology."

PARLIAMENTARY REPORTS.

SESSIONAL PRINTED PAPERS.

Par. Numb. *Delivered on 17th April*, 1866.

101. Bill—Elective Franchise.
4. (III.) Cattle Plague—Three Orders in Council.
5. (I.) Small-pox in Sheep—Three Orders in Council.
64. Sheriff Courts (Scotland)—Returns.
182. Army (Hong Kong)—Letter.

Delivered on 18th April, 1866.

104. Bills—Public Libraries Act Amendment (as amended).
105. ,, Convicts' Property.
107. ,, Local Government Supplemental.
15. (330 to 337) Railway and Canal, &c., Bills—Board of Trade Reports.
174. London (City) Traffic Regulation Bill—Special Report.
177. Habeas Corpus Suspension (Ireland) Act (Cork Gaol)—Return.
177. (I.) Habeas Corpus Suspension (Ireland) Act (Waterford Gaol)—Returns.
177. (II.) Habeas Corpus Suspension (Ireland) Act (Waterford Gaol)—Correspondence.
178. Barony of Farney—Return.
184. Cattle Plague (Scotland)—Order in Council.
Ecclesiastical Commission—Eighteenth Report of Commissioners.

SESSION 1865.

475. Public Accounts—Return.

Delivered on 19th April, 1866.

108. Bills—Superannuations (Officers Metropolitan Vestries and District Boards) (amended).
109. ,, Railway Debentures, &c., Registry.
15. (338 and 339) Railway and Canal, &c., Bills—Board of Trade Reports.
133. Treasury Chest—Account.
180. Army (Limited Service)—Returns.
181. Army (Hong Kong and Kowloon)—Statement.
183. Ceylon—Complaint.
Cattle Plague (Ireland)—Report by Professor Ferguson.
Ordnance Survey and Topographical Depot—Report.

Patents.

From Commissioners of Patents' Journal, April 20th.

GRANTS OF PROVISIONAL PROTECTION.

Aerated waters—927—R. Hineson.
Boats, towing—50—O. de Mesnil.
Bobbin net or lace machinery—969—F. Rebière.
Bones, treating—915—J. C. Martin.
Braiding and weaving machines—945—G. Davies.
Brewing, mashing grain used in—905—T. Ryder.
Brewers' refuse as a manure, application of—949—A. G. Lock.
Bridges—913—E. Kochs, T. Reuter, and O. Henrici.
Capsules, colouring—959—W. Betts.
Carpenter's plane—973—G. Muller.
Castors—3294—R. McL. Claypole.
Cheese—786—T. Manock.
Coke ovens—919—C. Pardoe.
Coke ovens—933—W. B. and E. J. Collis.
Concrete—975—T. W. Pearce.
Cork, cutting—963—M. Henry.
Cylindrical metallic rods and tubes, rolling, &c.—796—F.C.Bakewell.
Domestic polishing powder—955—G. P. Wheeler.
Drill and other braces—764—J. Varley.
Electro-magnetic power engines—931—W. Read.
Fabrics—782—T. Biggs, jun.
Fabrics—937—N. Legendre.
Fire-alarum—662—J. Crean and C. J. Barr.
Fire-alarum, self-acting—965—G. H. J. Simmons.
Fire-arms—760—E. Russ, and H. and E. Hammond.
Fire-arms, breech-loading—981—F. E. Walker.
Fire-escape—584—W. H. Prior.
Fire-escape—818—R. A. Jones and J. C. Hedges.
Glass—983—J. H. Johnson.
Grain, decorticating—917—H. E. Newton.
Guns, breech-loading—806—T. G. Sylven.
Jute and China grasses, treating—828—W. Clark.
Labels—961—R. Sweeting.
Leather cloth—907—T. Storey and W. V. Wilson.
Liquids, forcing—630—H. McPhail.
Lozenges, &c.—935—J. J. Derricy.
Machinery, controlling the speed of—882—T. Silver.
Manure, removal of—898—C. T. Liernur.
Manures—773—A. G. Lock.
Meals, sifting—909—M. Myers.
Metal articles, making—740—P. H. Ashberry.
Metallic plates, annealing—646—G. Prentice and A. B. Inglis.
Minerals, cutting—433—W. F. Cooke and G. Hunter.
Noxious gases, deodorizing of—941—E. Brooke, jun.
Photographic portraiture—820—W. S. Laroche.
Pianofortes—977—B. Johnson.
Pipes used for smoking, cleaning—943—M. P. E. Vors.
Portable chairs—410—T. Clift.
Rotary brushing and rubbing apparatus—939—C. Turner.
Rotary steam engine—778—W. Goodwin.
Safes—911—R. Noake.
Shafts, lubricating the journals of—858—W. Whittaker and W. Lowe.
Ships or vessels, bolts used in building—734—W. Simons.
Shirts—929—J. Blair.
Smokers, apparatus for—602—M. and M. Myers, and W. Hill.
Steam hammers—668—W. H. Berry.
Submarine and torpedo boat—766—S. S. Merriam.
Substances, bleaching—925—J. H. Johnson.
Surfaces, polishing—750—G. H. Smith.
Threads, spooling—3376—R. Smith.
Waste liquors, treating—812—T. Routledge, and T. and W. H. Richardson.
Wearing apparel—967—E. Pearson.
Weaving, looms for—903—R. M. Graystock.
Weaving, looms for—951—W. E. Newton.
Weaving, looms for—957—P. J. Macaigne.

INVENTIONS WITH COMPLETE SPECIFICATIONS FILED.

Springs—1039—A. H. Brandon.
Tobacco, cutting—1036—G. Haseltine.

PATENTS SEALED.

2742. W. Snell.	2829. L. Pebeyre.
2743. F. H. Gray.	3208. C. K. Tomlinson and C. J. Hayward.
2753. G. A. Huddart.	3297. W. F. Cooke and G. Hunter.
2767. G. W. Bacon.	58. H. N. Penrice.
2769. E. Heywood.	113. W. R. Lake.
2778. J. Combe.	116. C. N. Tyler.
2780. F. H. Gossage.	149. W. Lyne.
2781. S. Cotton.	168. G. Spencer.
2787. J. and J. Hinks.	186. G. T. Bousfield.
2828. B. F. Brunet.	

From Commissioners of Patents' Journal, April 24th.

PATENTS SEALED.

2765. W. Smith.	2833. J. Webster.
2766. L. Bennett.	2908. W. R. Lake.
2773. J. Garnett.	2996. A. V. Newton.
2774. J. Bernard.	3041. W. E. Newton.
2776. T. B. Jordan.	3042. W. R. Lake.
2784. W. and E. Westmoreland.	3043. W. R. Lake.
2793. E. Meldrum.	3044. W. R. Lake.
2794. R. Girdwood.	3052. H. E. Newton.
2797. G. E. Donisthorpe.	3099. T. Bell.
2798. D. P. G. Matthews.	3281. W. E. Newton.
2804. A. Deslandes.	3316. W. E. Newton.
2807. W. E. Newton.	34. F. Wright.
2808. H. Y. D. Scott.	460. H. B. Young.
2814. L. Pfeiffer.	509. H. Lea.
2822. W. E. Gedge.	
2824. M. Campbell, A. C. P. Coote, and J. C. A. H. Wolffram.	

PATENTS ON WHICH THE STAMP DUTY OF £50 HAS BEEN PAID.

2459. J. R. Johnson and J. A. Harrison.	993. H. Donald.
2514. J. R. Johnson and J. S. Atkinson.	995. W. C. Cambridge.
966. J. Goucher.	1006. G. B. Barber.
972. C. W. and F. Siemens.	1072. G. E. Donisthorpe.
978. P. G. Rowell and H. Holt.	1104. J. Purdey.
1023. J. Thompson.	1223. W. Clark.
1024. J. Thompson.	1000. F. Durand.
985. A. Ford and R. Rigg.	1007. J. W. Proffitt and W. L. Duncan.
992. H., E., S., and J. Yeadon.	1013. P. McGregor.

PATENTS ON WHICH THE STAMP DUTY OF £100 HAS BEEN PAID.

977. J. Freer.	1033. T. A. Weston.
1031. G. Ward.	1115. R. Mushet.
1010. T. S. Truss.	